



Water*for***Food**

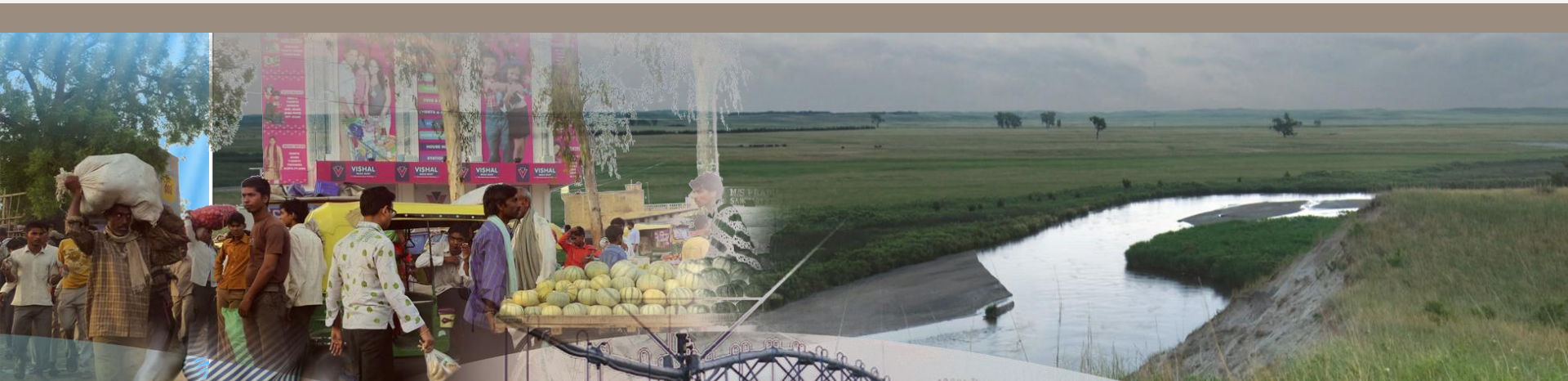
ROBERT B. DAUGHERTY INSTITUTE

at the University of Nebraska

AIRBORNE MAPPING OF EVAPOTRANSPIRATION ROLE OF PILOTED SYSTEMS IN THE FUTURE

Christopher M.U. Neale

Director of Research

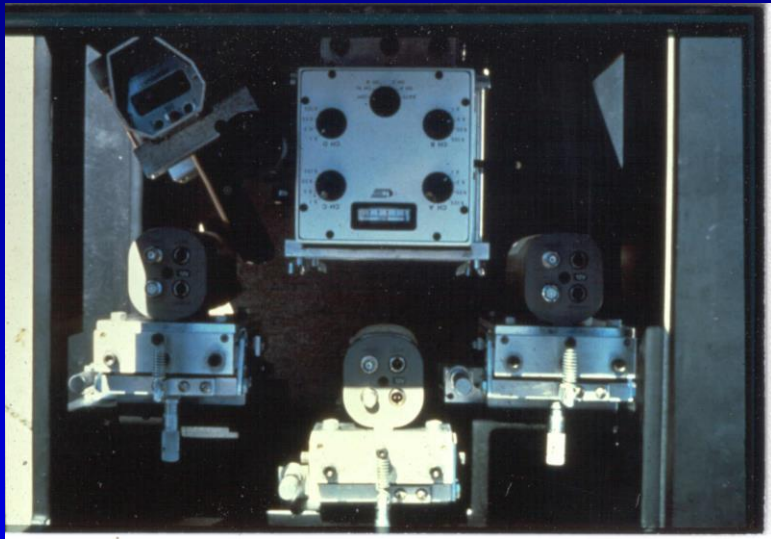


OUTLINE

- Example of a low-cost airborne systems
- Discussion about the niche of these systems
- Description of ET retrieval applications using high-resolution imagery
- Examples of International Applications

Evolution of Low-Cost Remote Sensing Technology at USU

USU Multispectral
Video/Radiometer System 1990



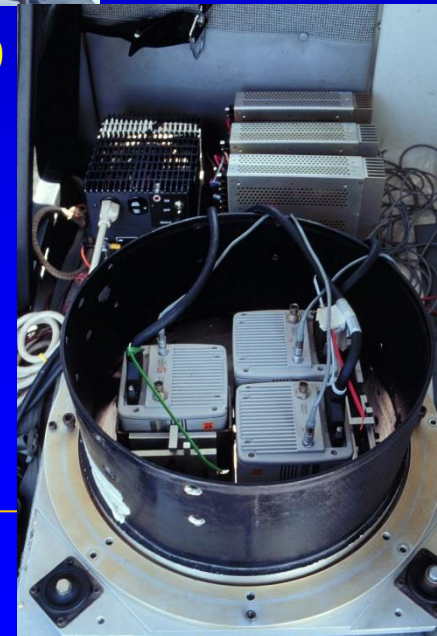
Approximate Cost: < \$60,000

Neale, C.M.U. and B.G. Crowther. 1994. Remote Sensing of Environment, Volume: 49 Issue: 3 Pages: 187-194.

USU Airborne Multispectral Digital System
1997



Approximate Cost: < \$150,000



LASSI 560 Airborne Lidar Multi-Sensor System



- Riegl LPM-Q560 lidar transceiver
- NovAtel SPAN-SE RTK LI/L2 GPS Antenna and Receiver
- Litton LN-200 Inertial Measurement Unit integrated into a NovAtel SPAN interface

Approximate Cost: \$850,000

Gila River Tile 212

Color and False Color Ortho Mosaic

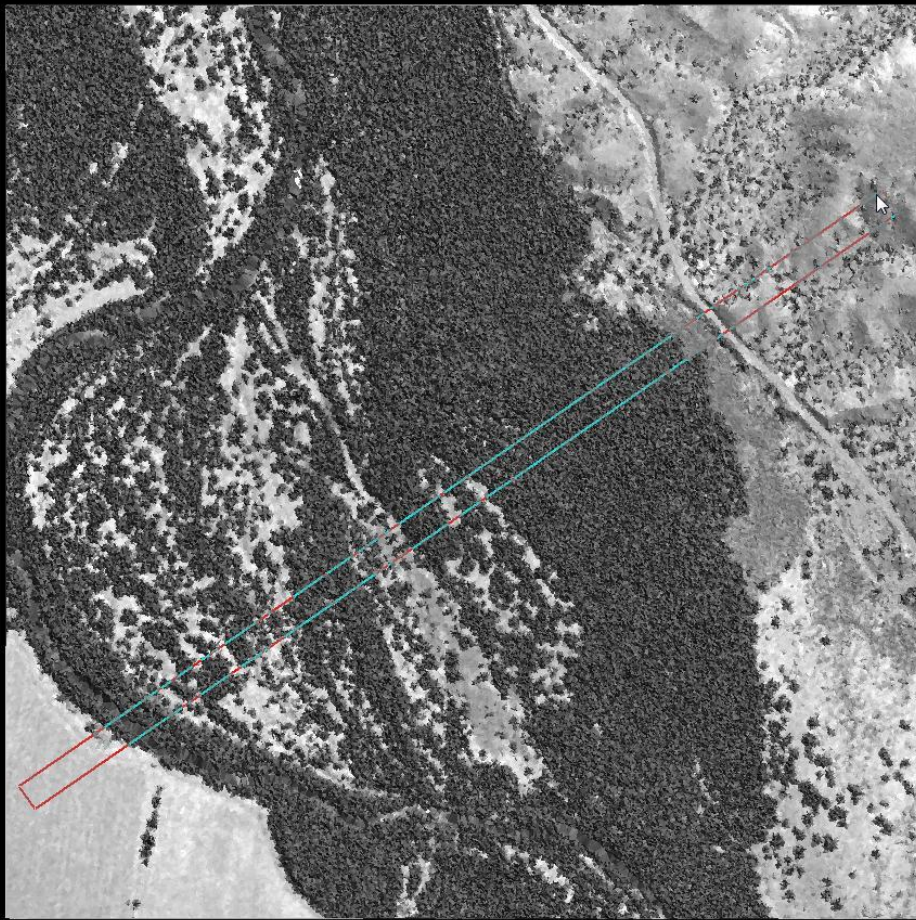
R,G,B

NIR, R, G

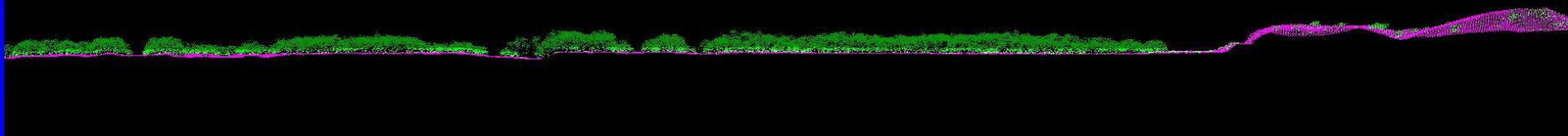
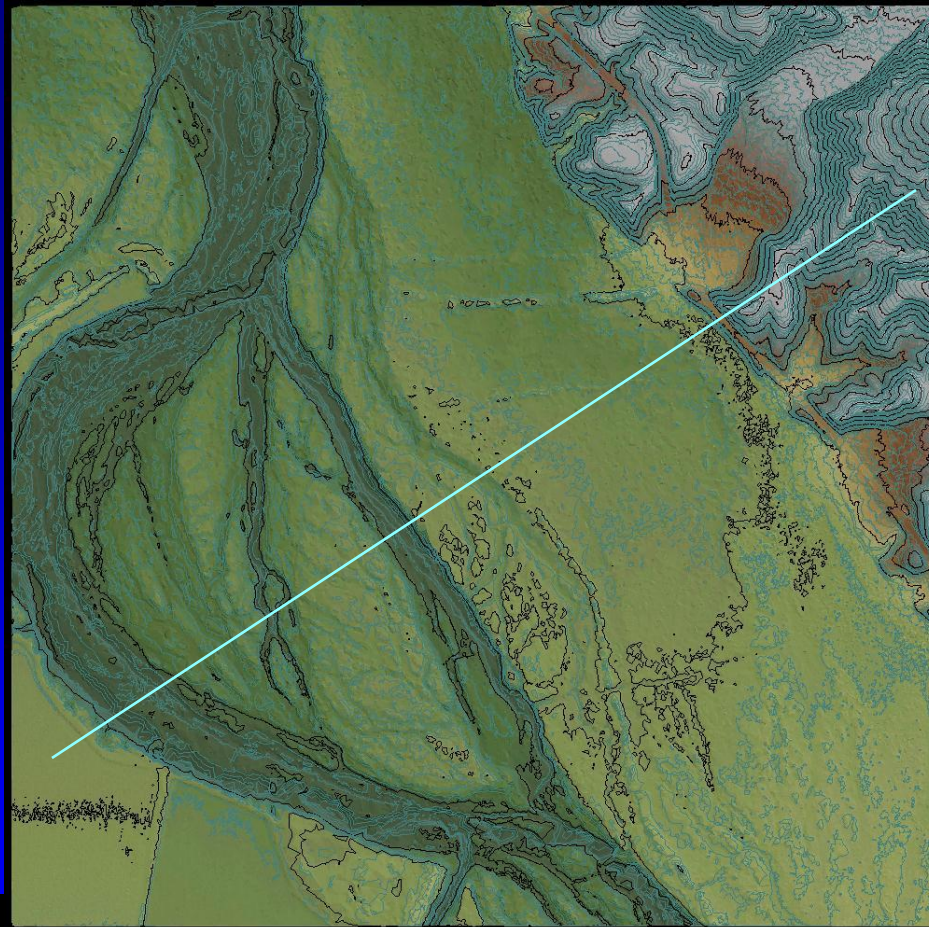


Gila River Tile 247

Point Cloud Intensity Cross-section



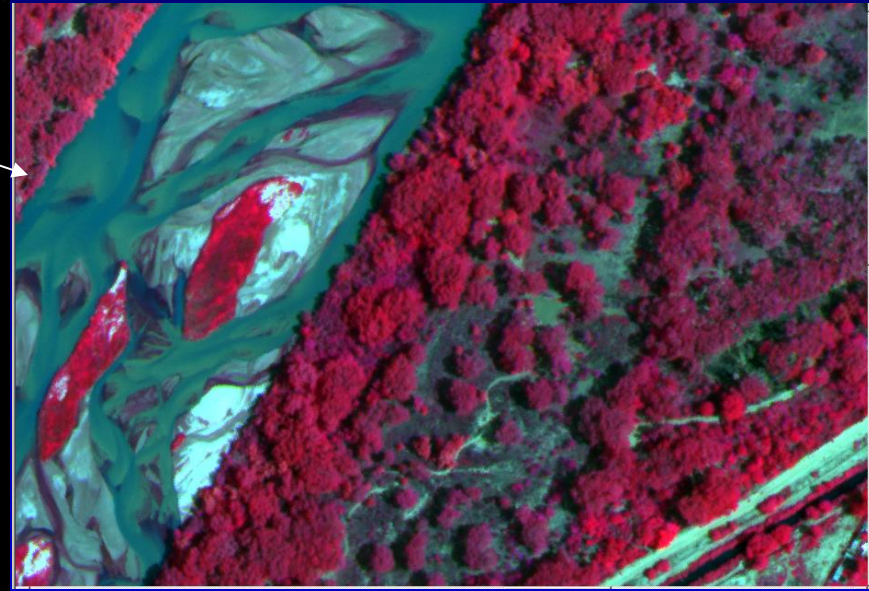
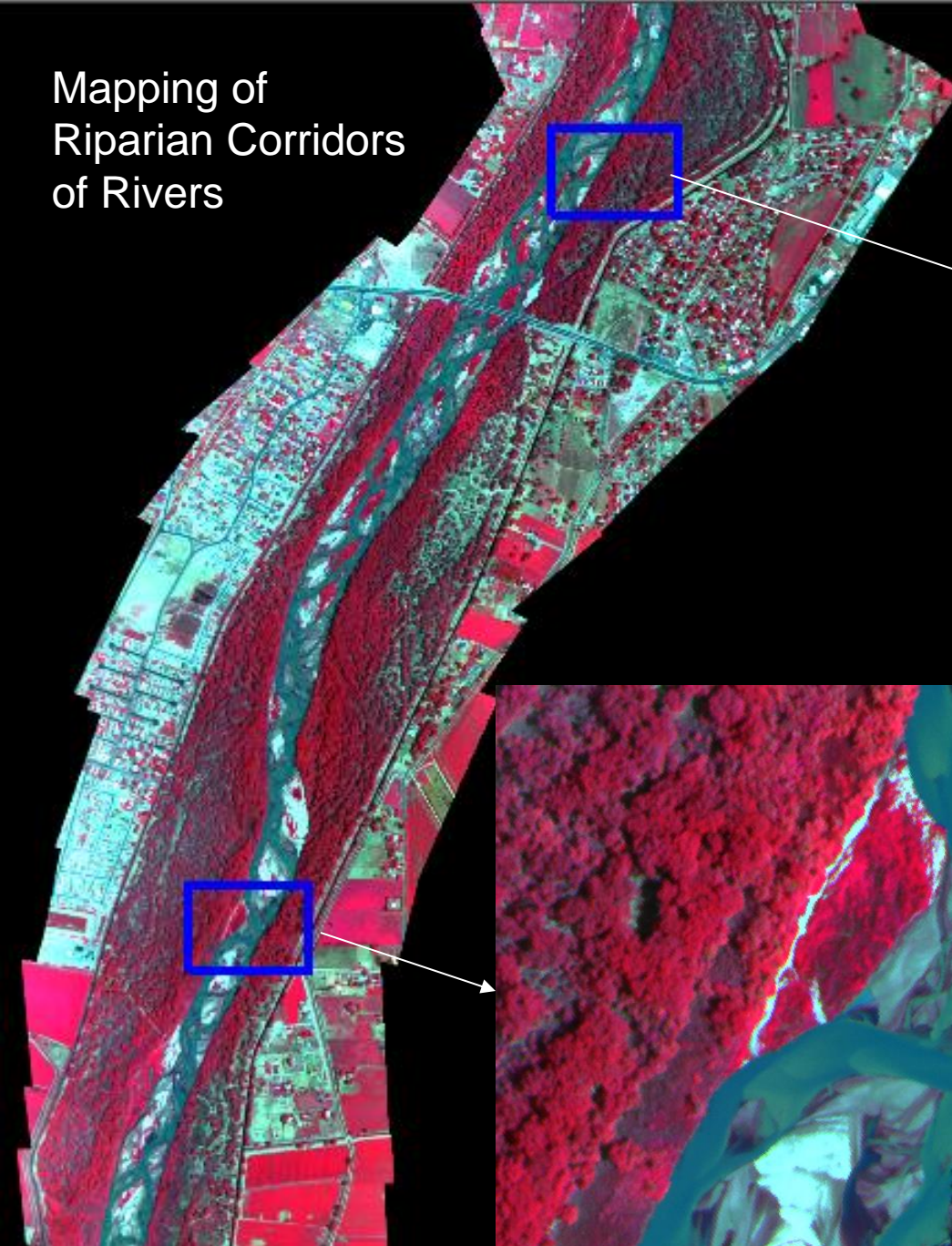
Ground surface TIN and Contours



AIRBORNE SYSTEMS FOR EVAPOTRANSPIRATION MONITORING

- High spatial resolution imagery (0.1 to 1.5 meters)
- Excellent for mapping surfaces and systems with small scale variability
- Provide an intermediate scale between ground-based ET flux tower measurements and satellite estimates
- Can cover areas up to hundreds of Kilometers cost effectively
- Can acquire data and imagery in a timely manner (subject to weather) to match scientific needs or vegetation phenology
- Costs depend on size of area flown and distance from home base (economy of scale)
- Scientific and monitoring/mapping applications

Mapping of Riparian Corridors of Rivers



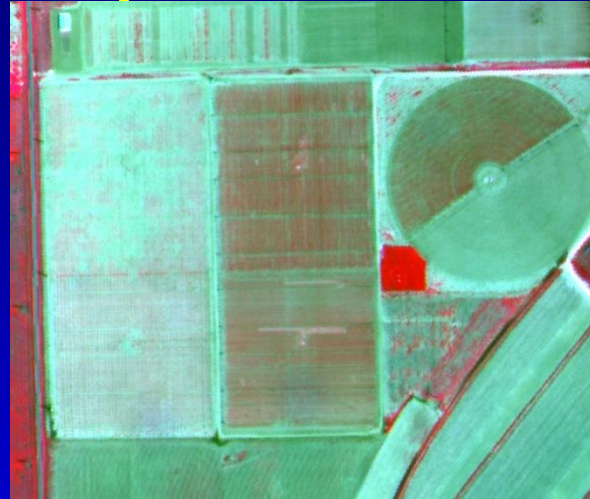
Multitemporal Sequence of Multispectral Images

– BEAREX 2008 – Bushland Texas

June 26



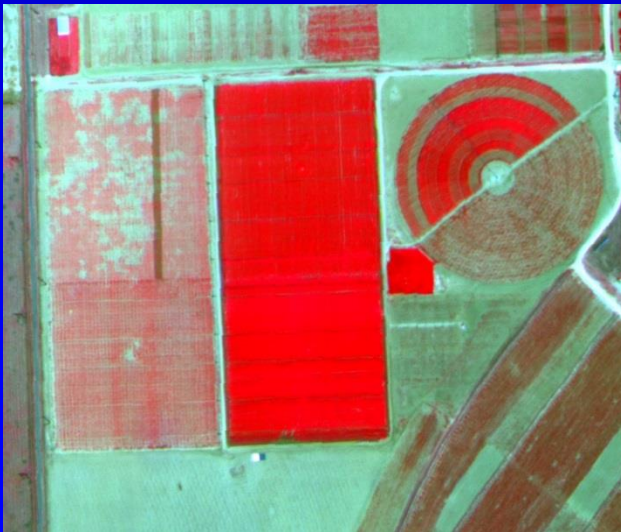
July 12



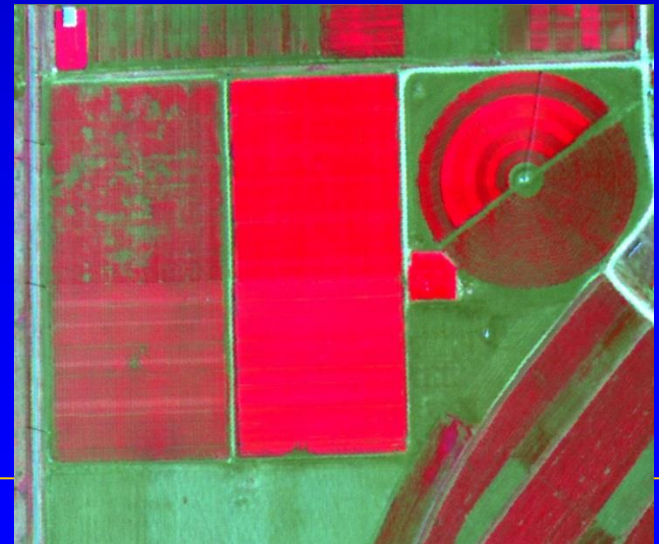
July 28



August 5



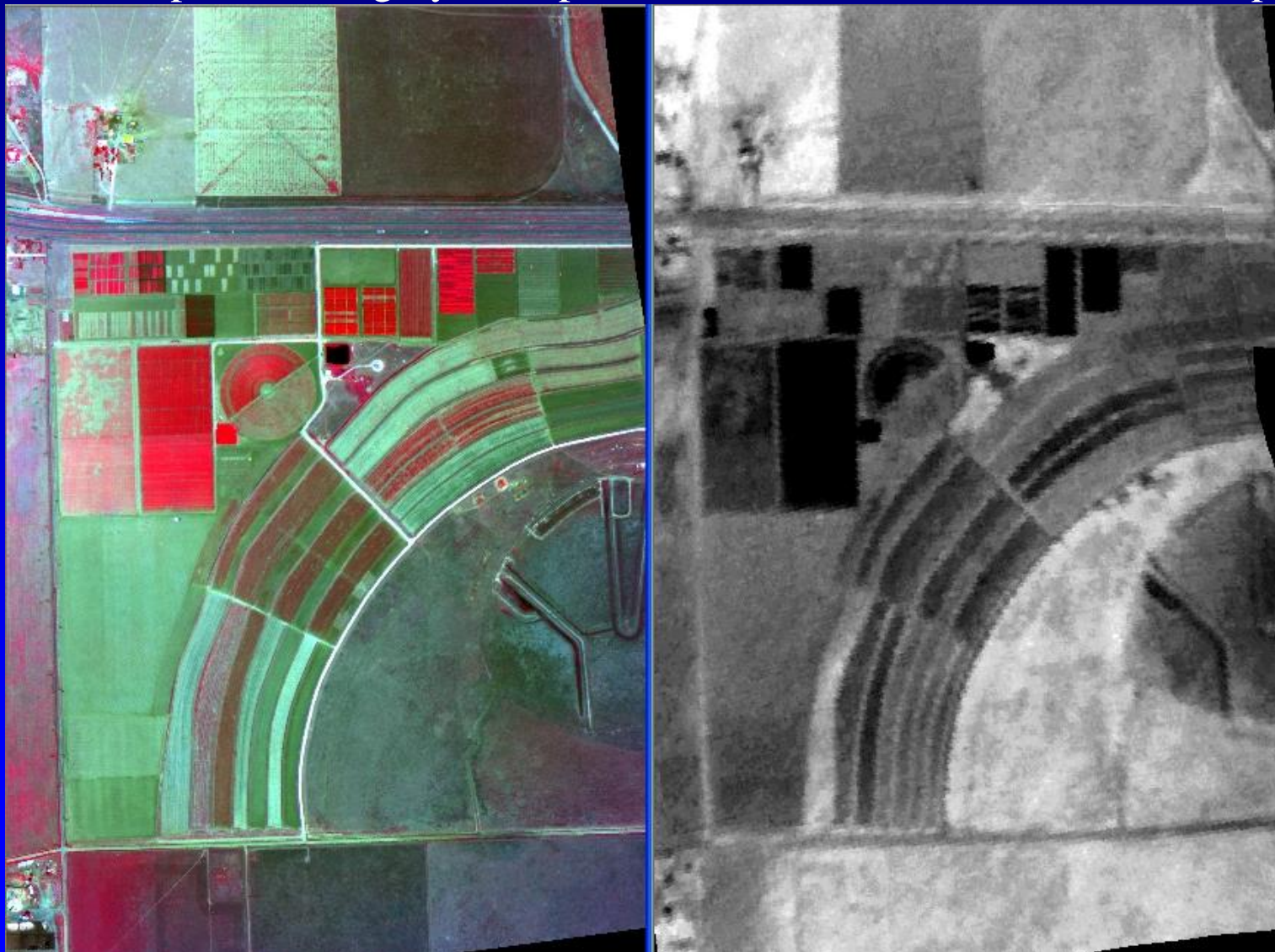
August 13



BEAREX 2008: Lysimeter/Flux Tower Mosaics

Acquired around the satellite overpass time
July 28, 2008

3 Band Multispectral Imagery 1-m pixel Thermal infrared mosaic 3.5-m pixel



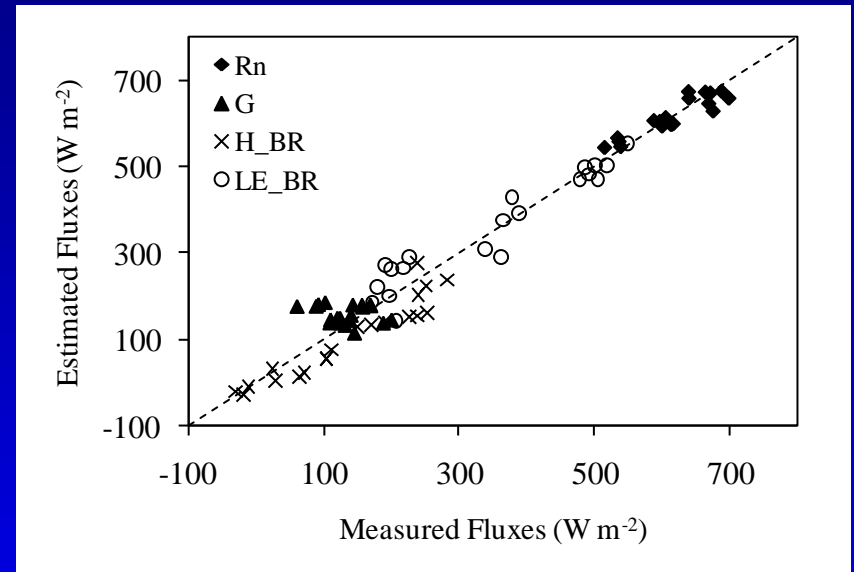
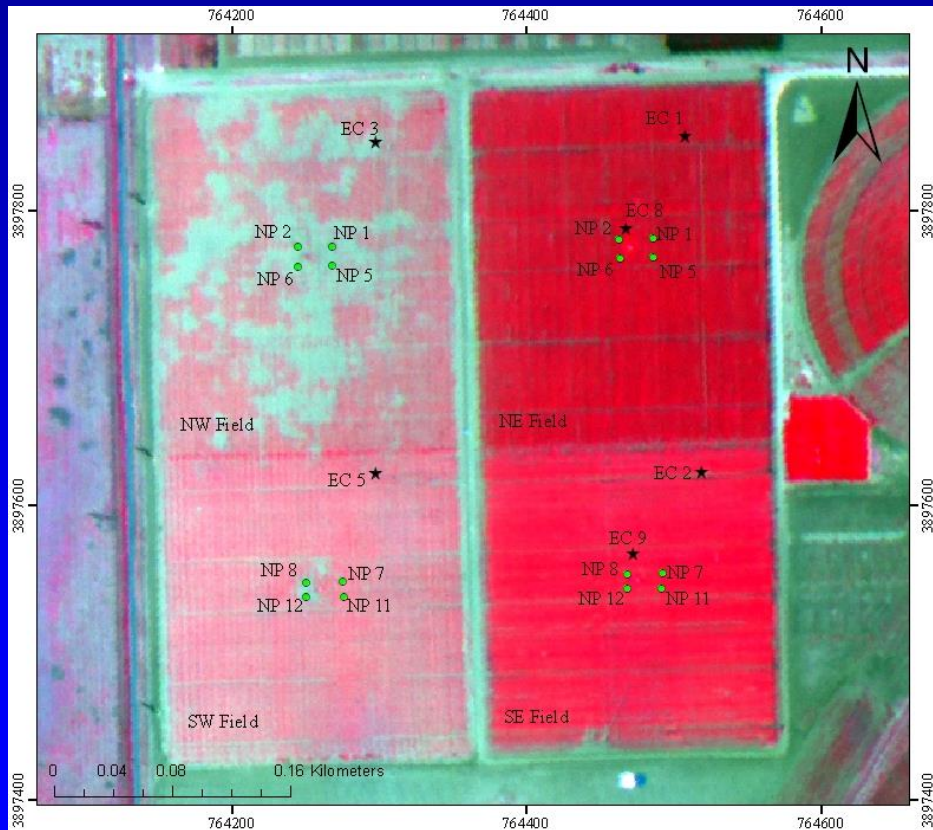
Application of the SETMI Hybrid ET Model

BEAREX 2008 – Bushland Texas

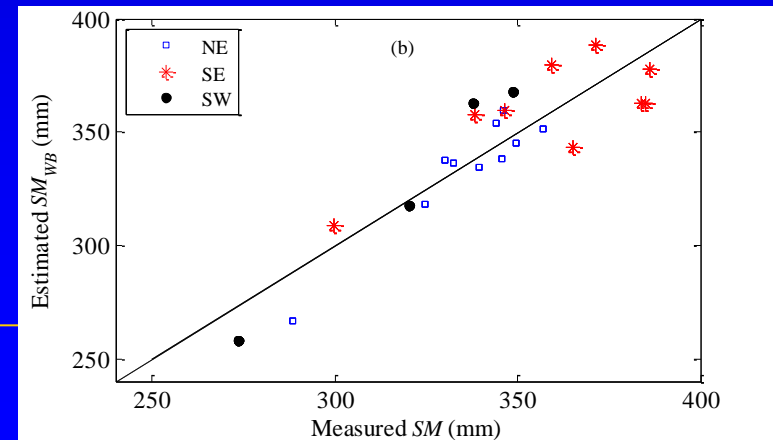
Rain Fed and Irrigated Cotton

3 Band Multispectral Imagery 1-m pixel July 28th, 2008. Green dots: Neutron Probe Access tubes

Comparison of Measured vs Estimated Fluxes



Estimated Soil Moisture vs Measured



Study Overview: Mapping of 94 miles of Mojave River Floodplain



Saltcedar (*Tamarix*)

- **Analyses included:**
 - 2007 and 2010 classification of native and non-native vegetation
 - Vegetation evapotranspiration modeling
 - Lidar elevation map development
 - Groundwater mapping
 - Water evapotranspiration cost calculations
- **Results are presented as a whole and also by Mojave Water Agency Alto, Alto Transition, Centro, and Baja subarea boundaries.**

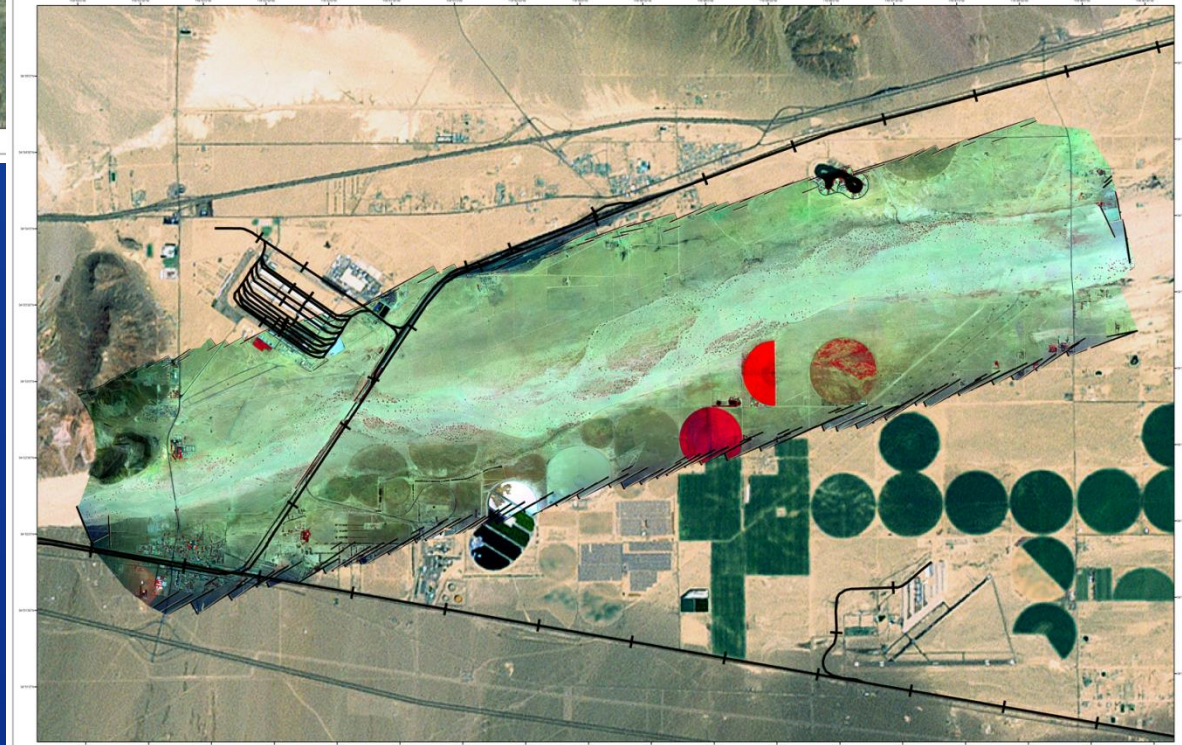


RECLAMATION

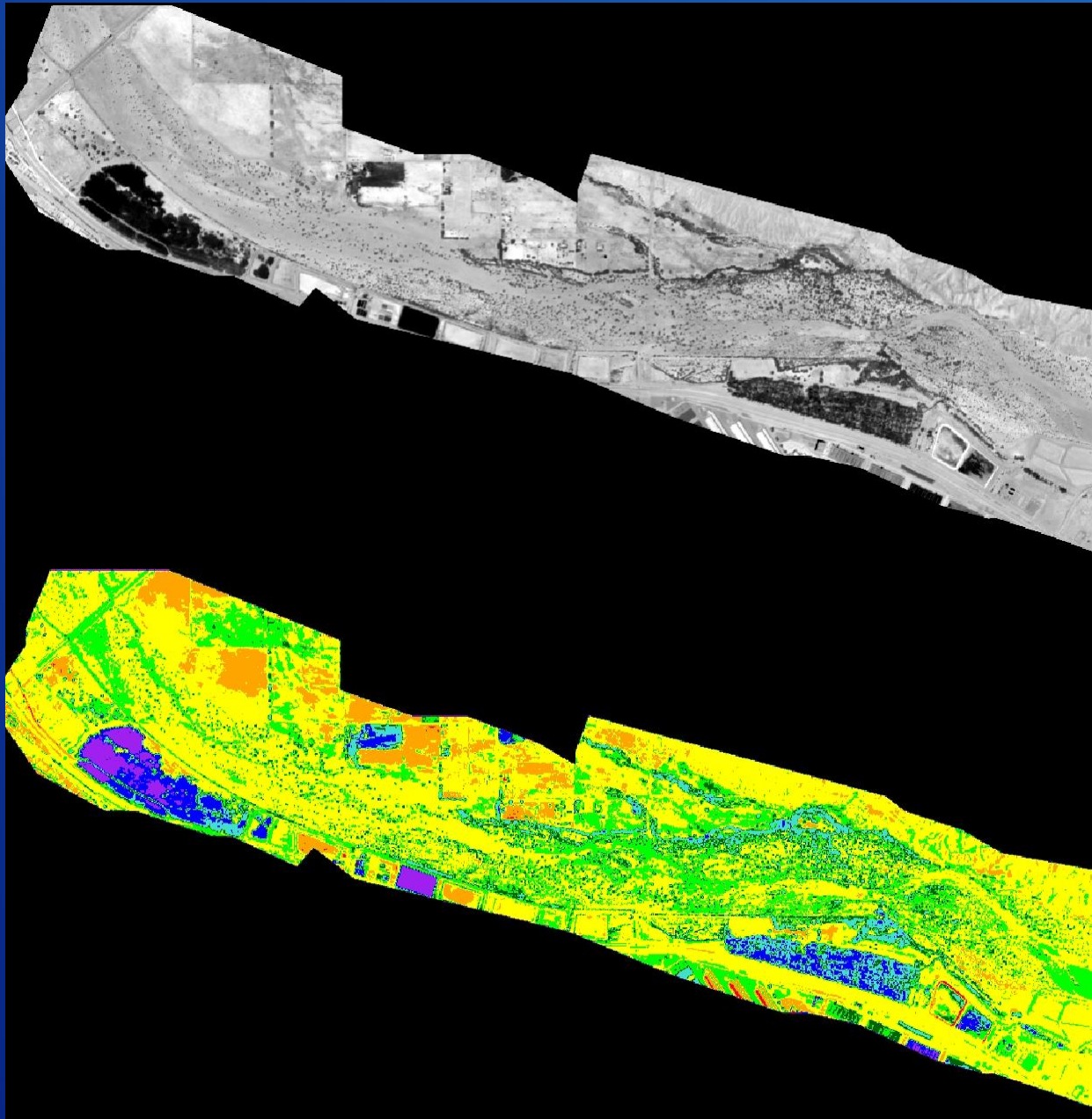
Multispectral Ortho Imagery

Block 1 and 2

Ortho-rectification
using direct geo-
referencing with Lidar
point cloud data



Thermal infrared Imagery: 1-meter pixel resolution



Temperature



20 – 30 °C



30 – 35 °C



35 – 40 °C



40 – 45 °C



34 – 50 °C



50 – 55 °C



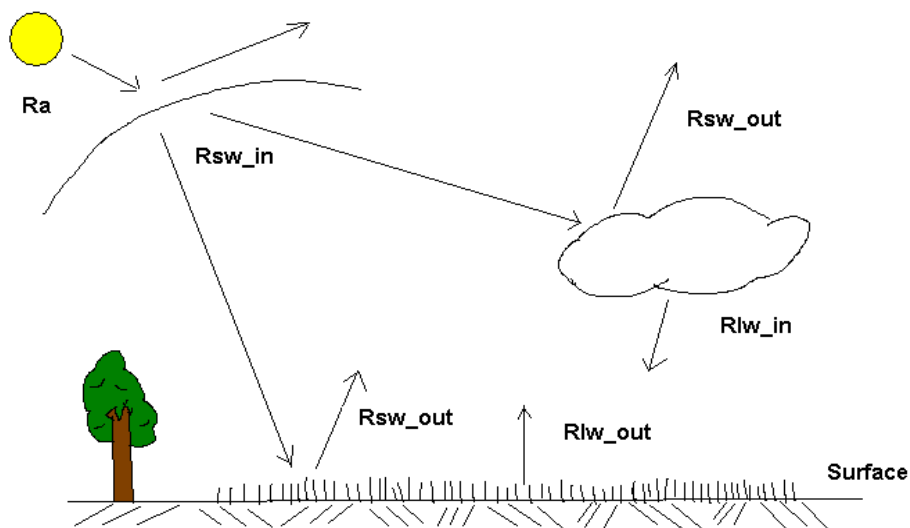
55 – 60 °C



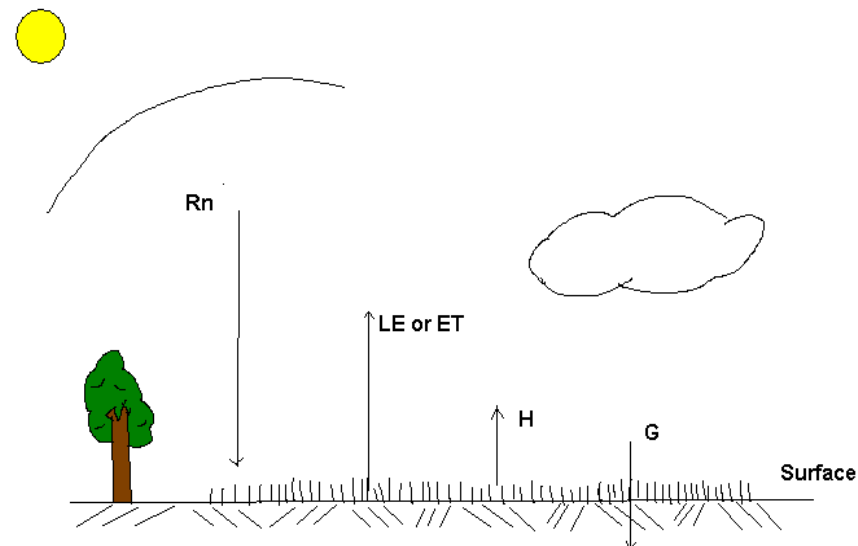
> 60 °C

ATION

Energy Balance Approaches Used to Estimate Evapotranspiration:



$$R_n = R_{sw_in} - R_{sw_out} + R_{lw_in} - R_{lw_out}$$



$$R_n = G + H + LE$$
$$LE = ET = R_n - G - H$$

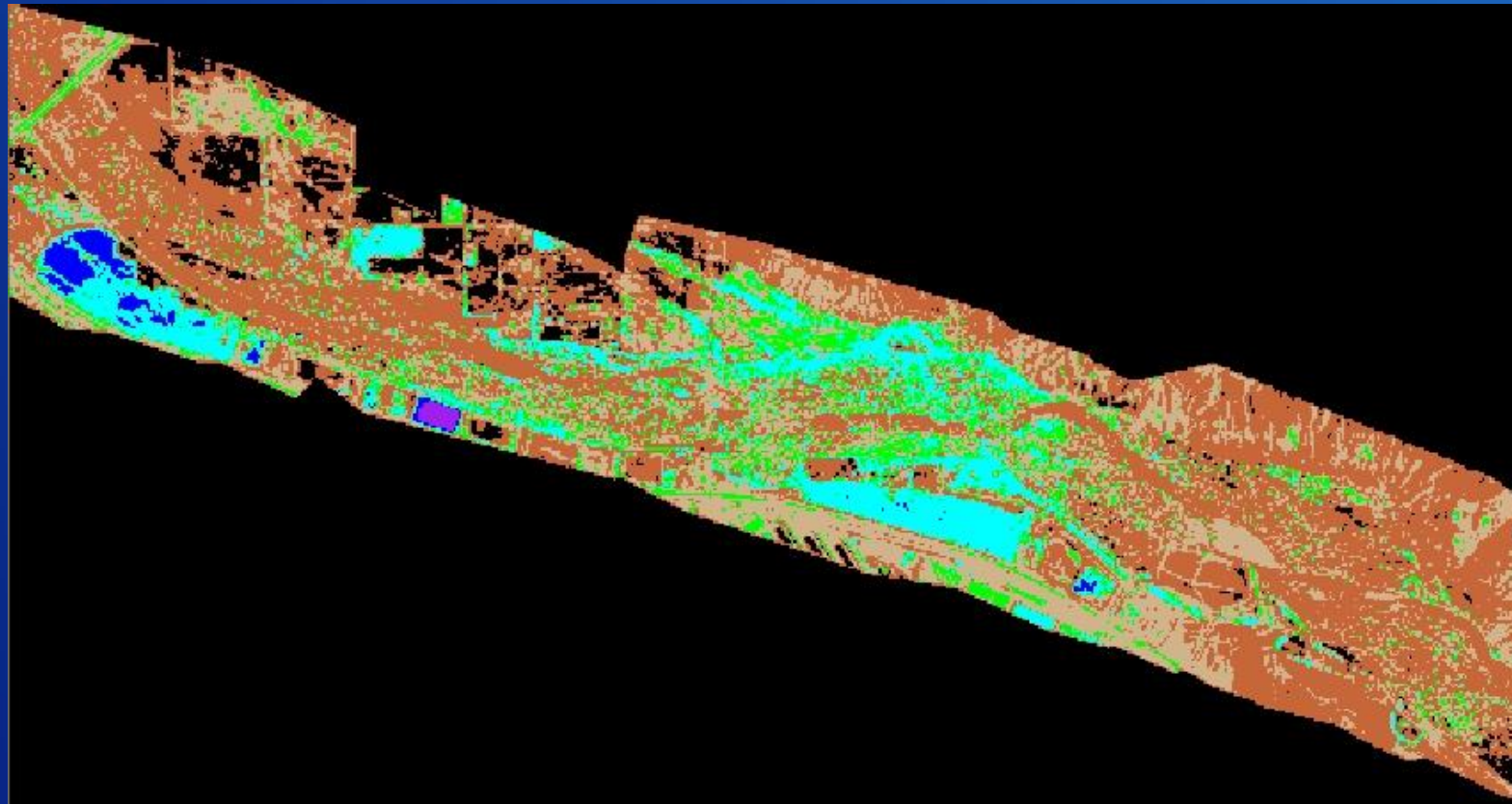
The Two-source model

SEBAL: Surface Energy Balance for Land

“Crop” coefficient model used to extrapolate over the growing season

RECLAMATION

SEBAL ET Results for Block 1



Past International Uses of the Airborne Multispectral Technology

- Mapping the Paraguay-Parana Waterway (Hidrovia) in South America (1995) as part of the environmental impact studies. Used high-resolution imagery to air-truth the satellite imagery.
- An airborne system was built for CODEVASF in Brazil and installed in their aircraft after modifications (1994). System used to monitor irrigated agriculture and the San Francisco river corridor.
- Airborne multispectral imagery was used to map irrigated areas in the Dominican Republic to identify salinity and drainage problems (2000 – 2004). Project funded by IDB (PROMASIR) and WB (PROMATREC)

Basic Studies for Management of Irrigation Systems

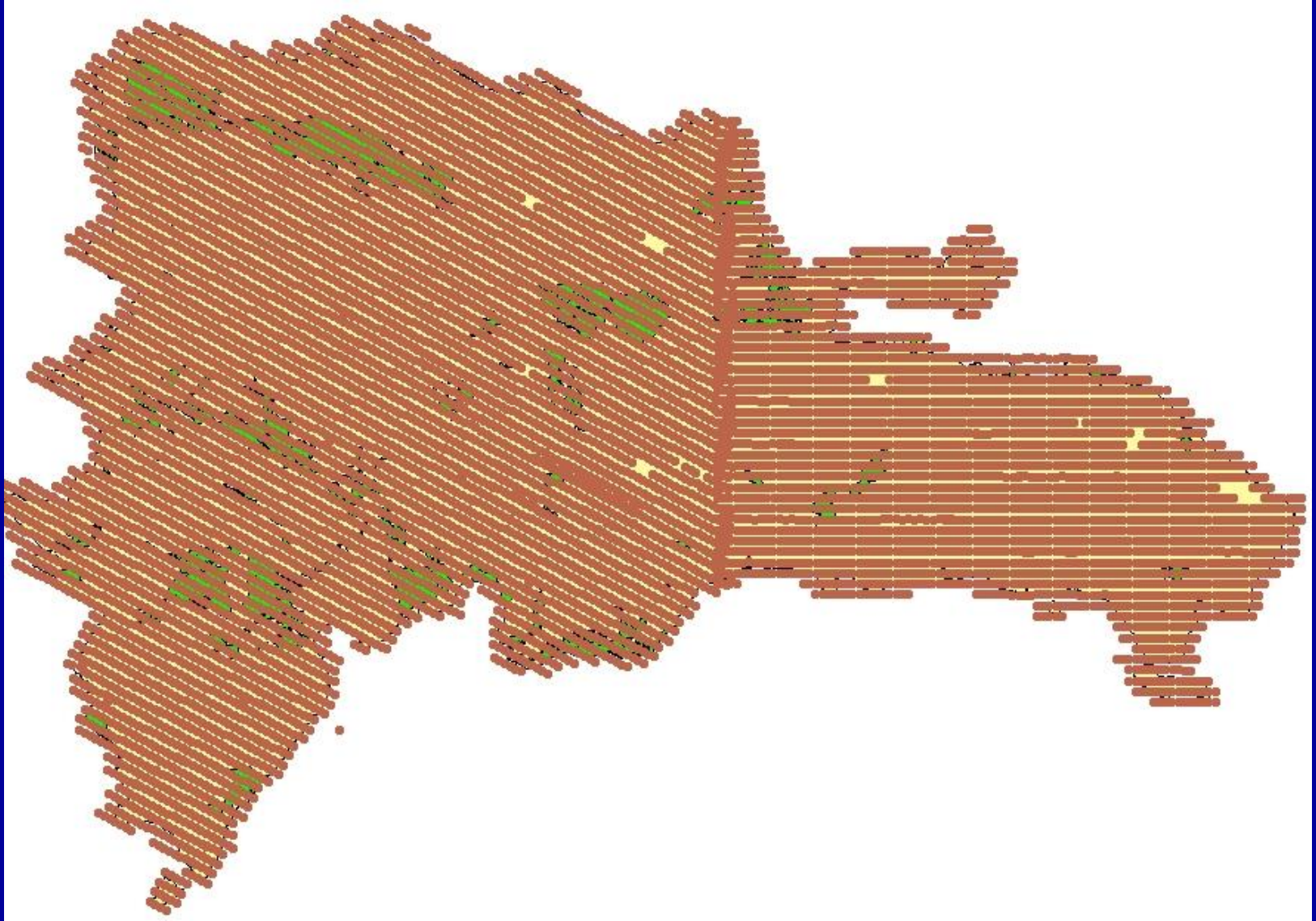
- Contract between INDRHI and (Utah State University) funded by the Inter-American Development Bank
- \$7.9 million dollars
- Duration: 4 ½ years
- Comprised 4 studies:
 1. Aerial Photography of the Entire Country
 2. Cadastre of Water Users (Padrón de Usuarios)
 3. Hydro-Agricultural Information System
 4. Monitoring of Salinity and Drainage Problems

These studies had the objective of providing basic information required for the transfer of Operation and Maintenance of 30 canal-based irrigation systems from the government control (INDRHI) to newly formed Irrigation Water User Associations



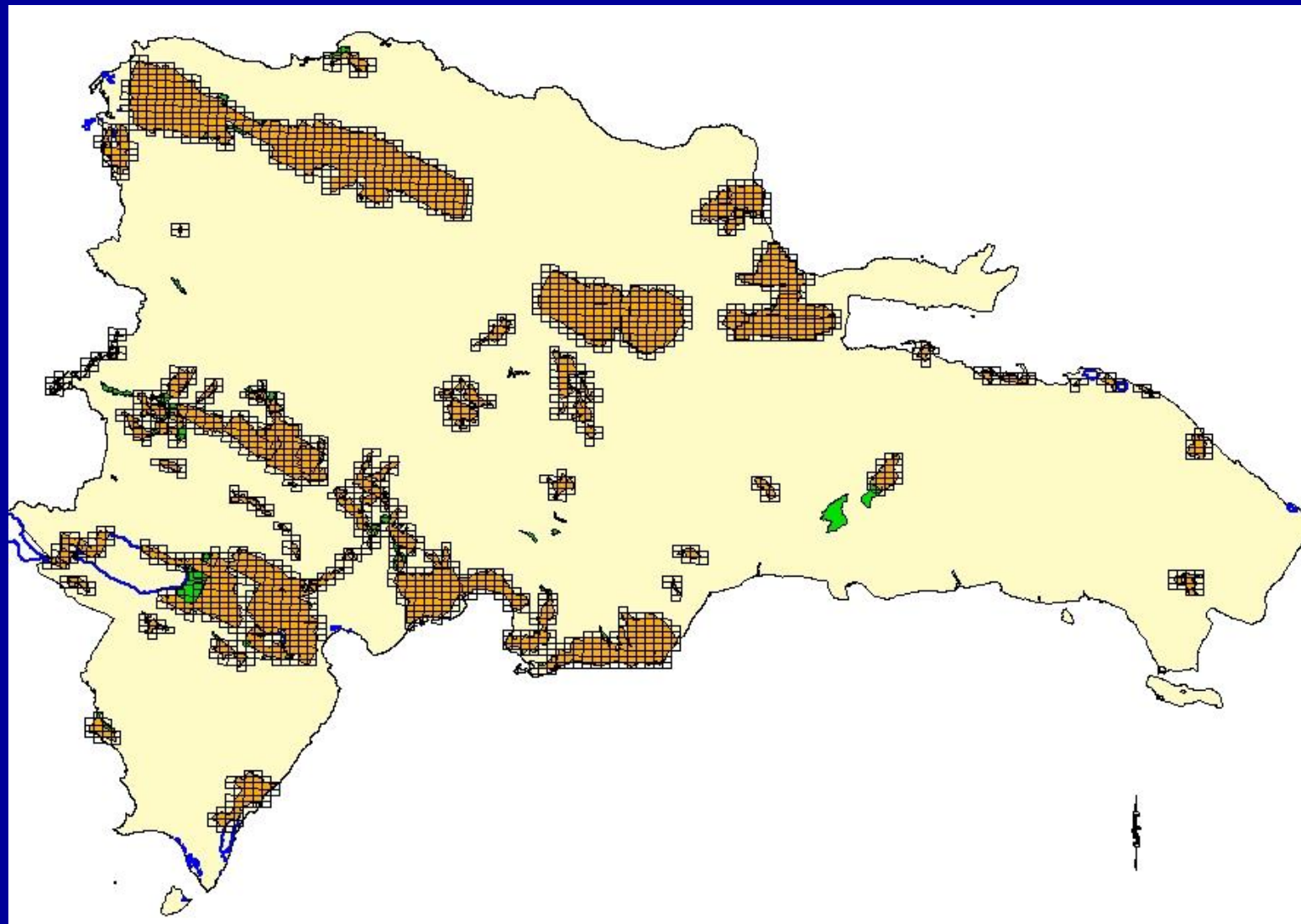
Final Results of the Aerial Photography Campaign

99.6 % of the Country covered with color photographs at 1:20000 scale



Digital Orthophotos

covering 4430 Km² of irrigated areas in the country



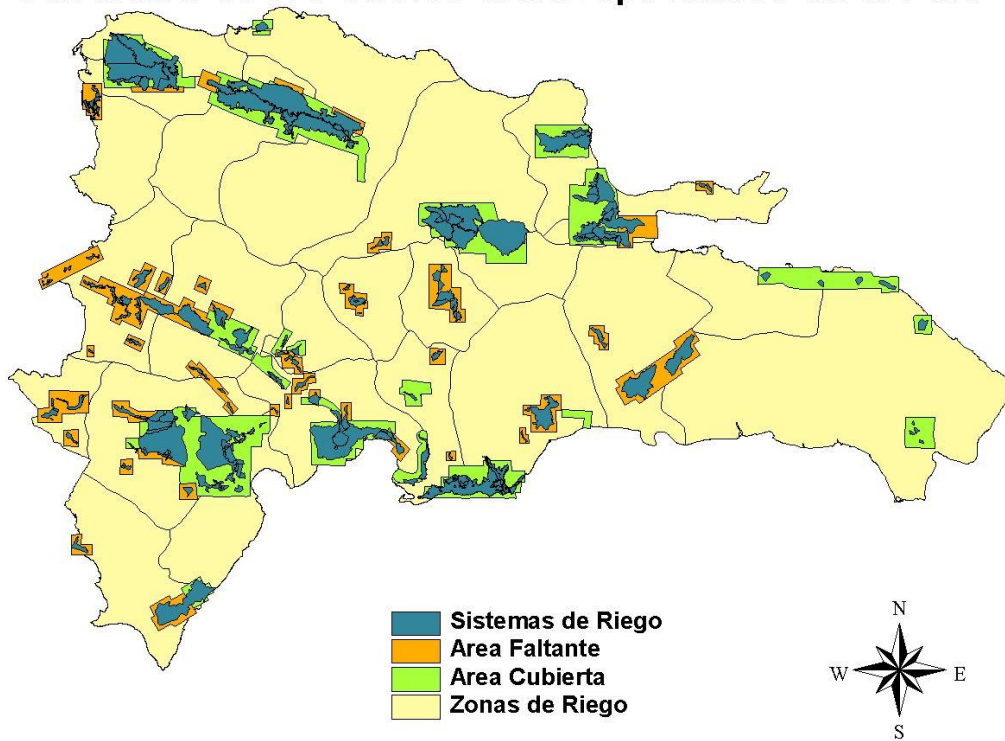
Printed Orthophoto at 1:4000 scale were used for field verification of property boundaries



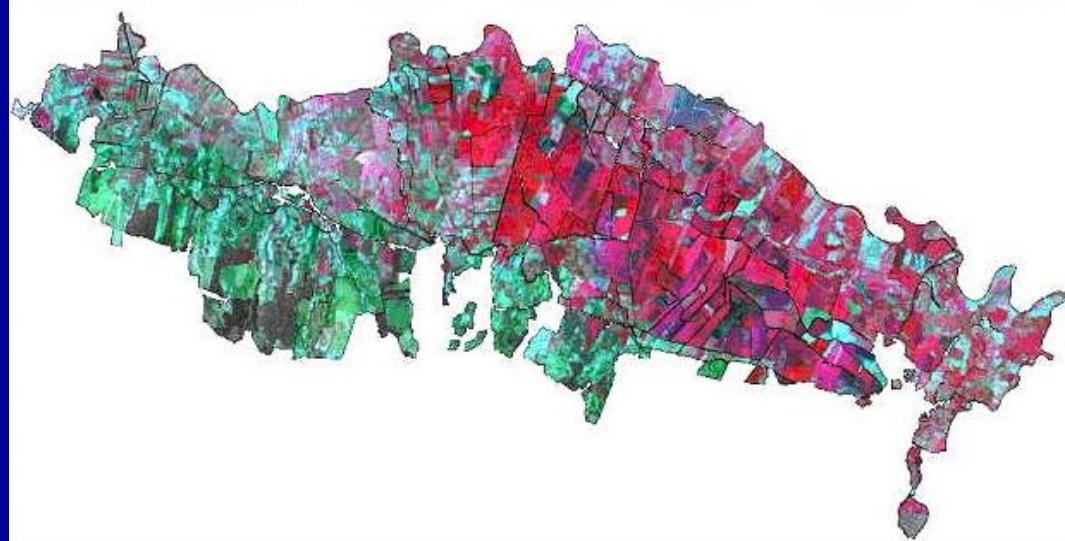
Field brigades used printed and laminated maps to identify the property boundaries together with the land owner or a local facilitator that has a good knowledge of the irrigation system (president of a water association, ditch rider)

A brigade consisted of 4 to 6 trained cartographers with one 4x4 dual cabin pickup and 3 or 4 cross-country motorbikes

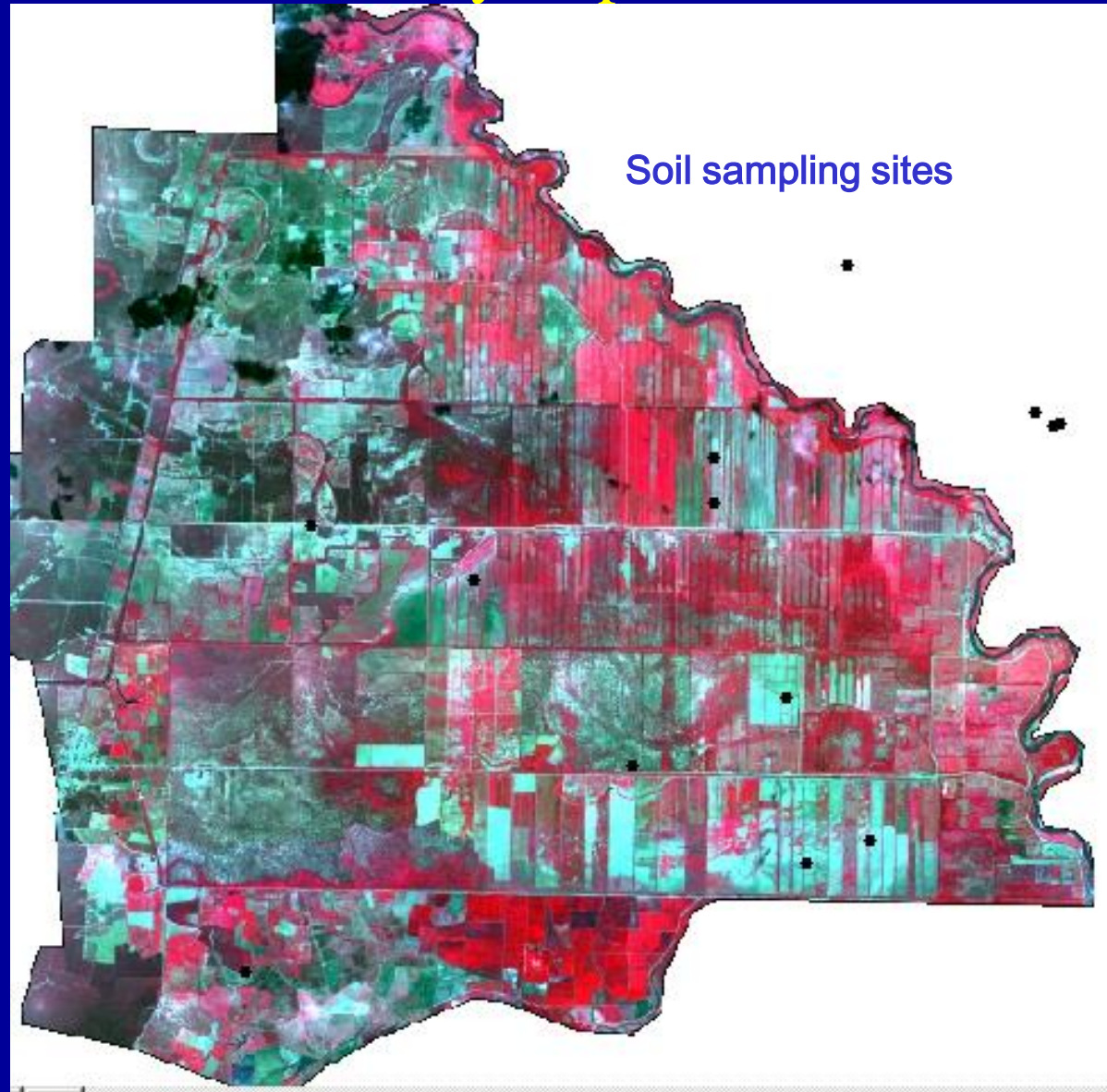
Cobertura de los Vuelos Multiespectrales en el Pais



Multispectral Mosaic of The Mao-Gurabo Irrigation System



Multispectral Mosaic of the Manzanillo Area used for Salinity Impact studies



Results were verified with intensive soil sampling

Conclusions and remarks

- Airborne imagery is a useful tool for estimating evapotranspiration of natural and agricultural vegetation with high spatial variability
- Intermediate scale between ground and satellite measurements
- Use of these systems in an international context will depend on the needs of a water agency or the private sector in a particular country for data and information beyond what present satellite systems can offer